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OFFICE MEMORANDUM

TO : Greg Nunz, G-DO

DATE: December 4, 1980

FROM : Hugh Murphy HM

SUBJECT : RESERVOIR ENGINEERING REPORT FOR NOVEMBER 1980

SYMBOL : G-5

MAIL STOP: 981

PHASE I

The current status of Run Segment 5 is summarized below

STATUS OF RUN SEGMENT 5 (EXPERIMENT 217)
AS OF 0800 November 21, 1980

Operating hours to date:	6308 hrs
Injection pressure - EE-1	1221 psi
Production pressure - GT-2	201 psi
Surface temperature at GT-2	136.6°C
Downhole temperature in GT-2 at 8500 ft	151.1°C (as of 11/3/80)
Production flow rate	82 gpm
Makeup flow rate	28.1 gpm
EE-1 annulus flow rate	21.5 gpm
Impedance (corrected for buoyancy)	15.5 psi/gpm
Current power level	2.19 MW
Total energy extraction	13,757,946 kWh (as of 11/20/80)

Total makeup and EE-1 annulus flow rates are 28 and 21 gpm respectively, indicating a net loss of 7 gpm, typical of downhole losses that prevailed before the EE-1 annulus began leaking. Computer matches with the data, using the wellbore heat transmission code WBHT indicates that the temperature of the leakage flow entering the EE-1 annulus at 8900 ft is about 150°C, indicating that this flow transits a significant fraction of the reservoir system before entering the annulus. Additional calculations indicate that the annulus flow rate could increase to as high as 200 gpm during the high pressure stress unlocking experiment scheduled for Dec. 8-12 before boiling would occur in the annulus.

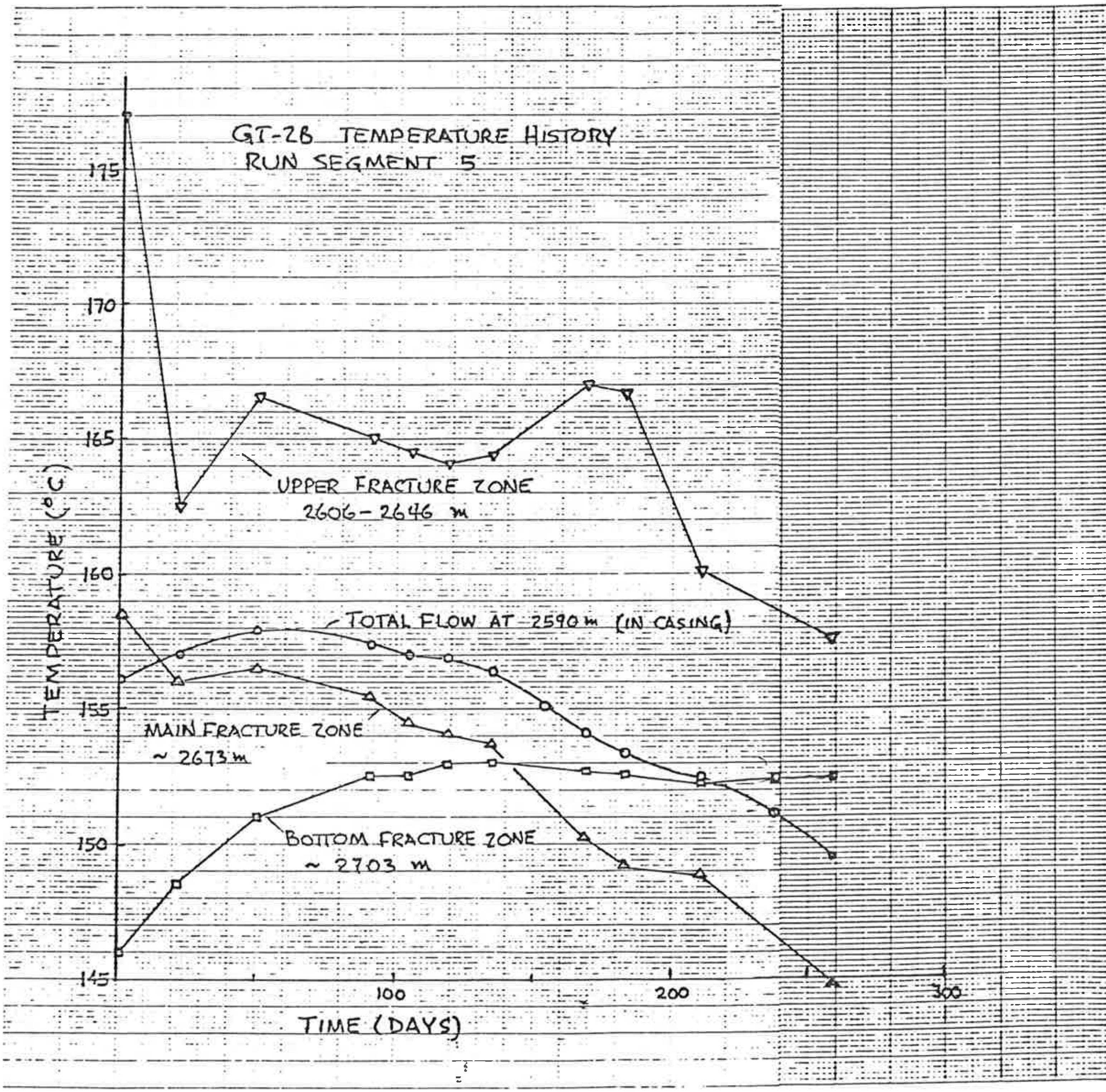

Figure 1. Thermal history of fracture zones at their intersections with the GT-2B production well.

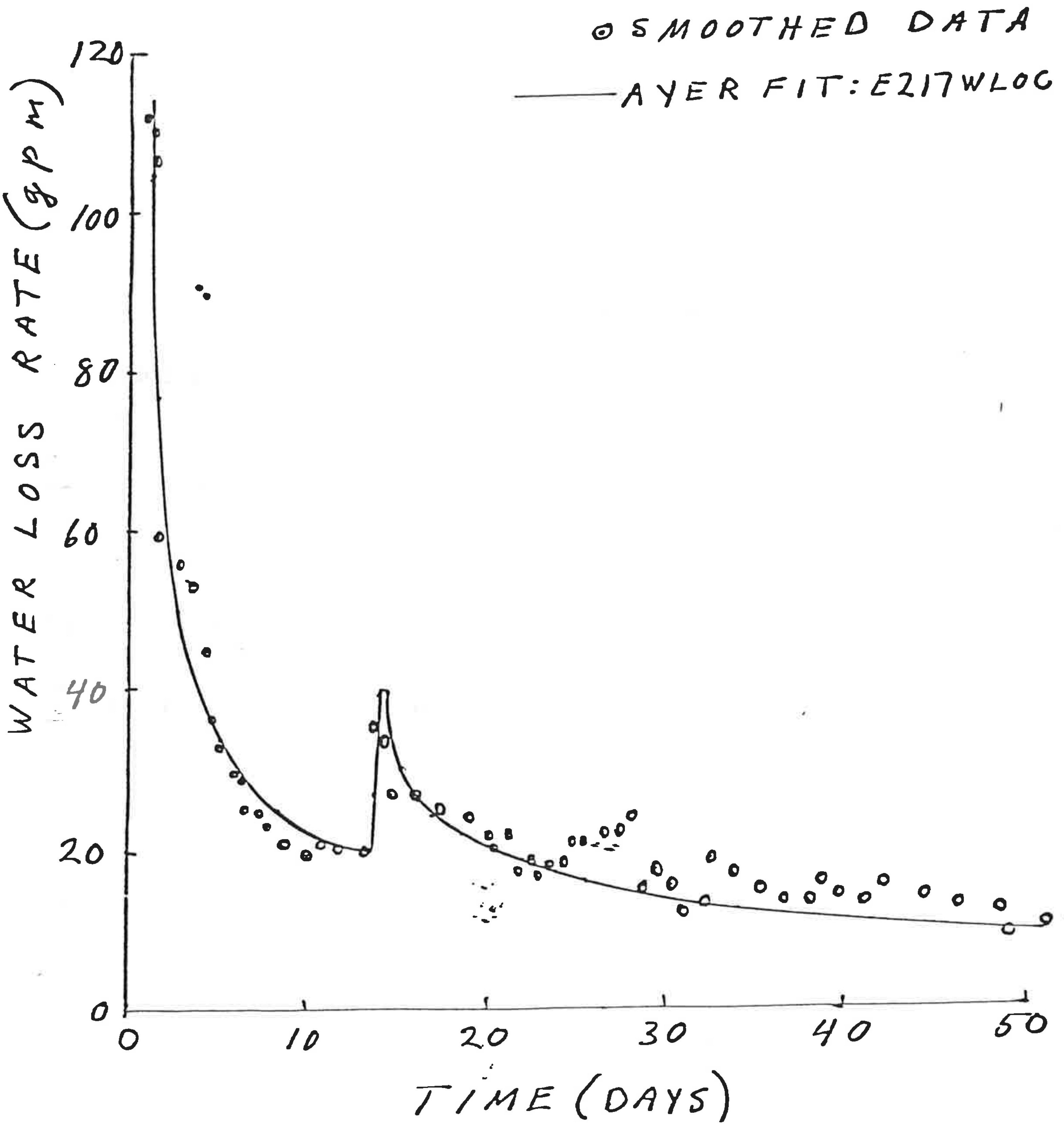

Figure 2. Comparison of measured and computed water loss rates.

Thermal Results. A temperature survey was run in well GT-2B on 11/3 and a combined temperature and spinner-flow rate survey was run in GT-2B on 11/24. Figure 1 summarizes the temporal behavior of several flow paths at the points where these paths intersect the production well GT-2B. As usual the curve labeled TOTAL FLOW represents the mean outlet temperature of the reservoir. The thermal drawdown, i.e., the mean temperature decrease with time, continues to be consistent with a total, one-sided heat exchanger area of 50,000 m^2, when the reservoir is interpreted as the combination of (1) a single large fracture, representing the new fracture originally from 9600 ft, which was created as a result of fracturing Experiments 203 and 195; and (2) a volumetric source of heat, representing the thermally depleted and fractured old fracture system originating at 9050 ft. Another model which treats the reservoir as four separate fractures results in a total, one-sided area of ~45,000 m^2, in reasonable agreement with the first estimate. Analysis of the GT-2B temperature surveys also indicates that the 0.14 MW(t) heat loss that formerly occurred at 960 to 1140 ft, which was removed by injection of N_2 gas into the outer annulus during October, is still absent, indicating that no significant amount of the gas has leaked off.

Water Losses. The early time (up to 50 days) water loss data for Run Segment 5 has been examined using the same one-dimensional pressure dependent model that was used to analyze the Segment 2 and 3 data. The AYER diffusion program was used. A typical calculated fit to the smoothed data is shown in Fig. 2. The results indicate that the new system is only slightly larger from a water loss standpoint (perhaps 30%) than the Segment 2 system.

PHASE II

(a) Wellbore Mapping. Analysis of EE-3 drilling trajectory and corrections to it continue.

(b) Geophysical Logging. Figure 3 shows the results of an EE-2 temperature log. Similar depths and temperatures are expected in EE-3, currently being drilled. Several features that affect logging are pointed out below:

(1) If a logging tool's temperature limit is 235°C (455°F) we cannot expect, without cooling, to log any of the open hole below the casing.

(2) If the temperature limit is 260°C (500°F), only ~800 feet of true vertical depth could be logged below the casing.

(3) To log the entire open hole the tool capability must be 320°C (610°F).

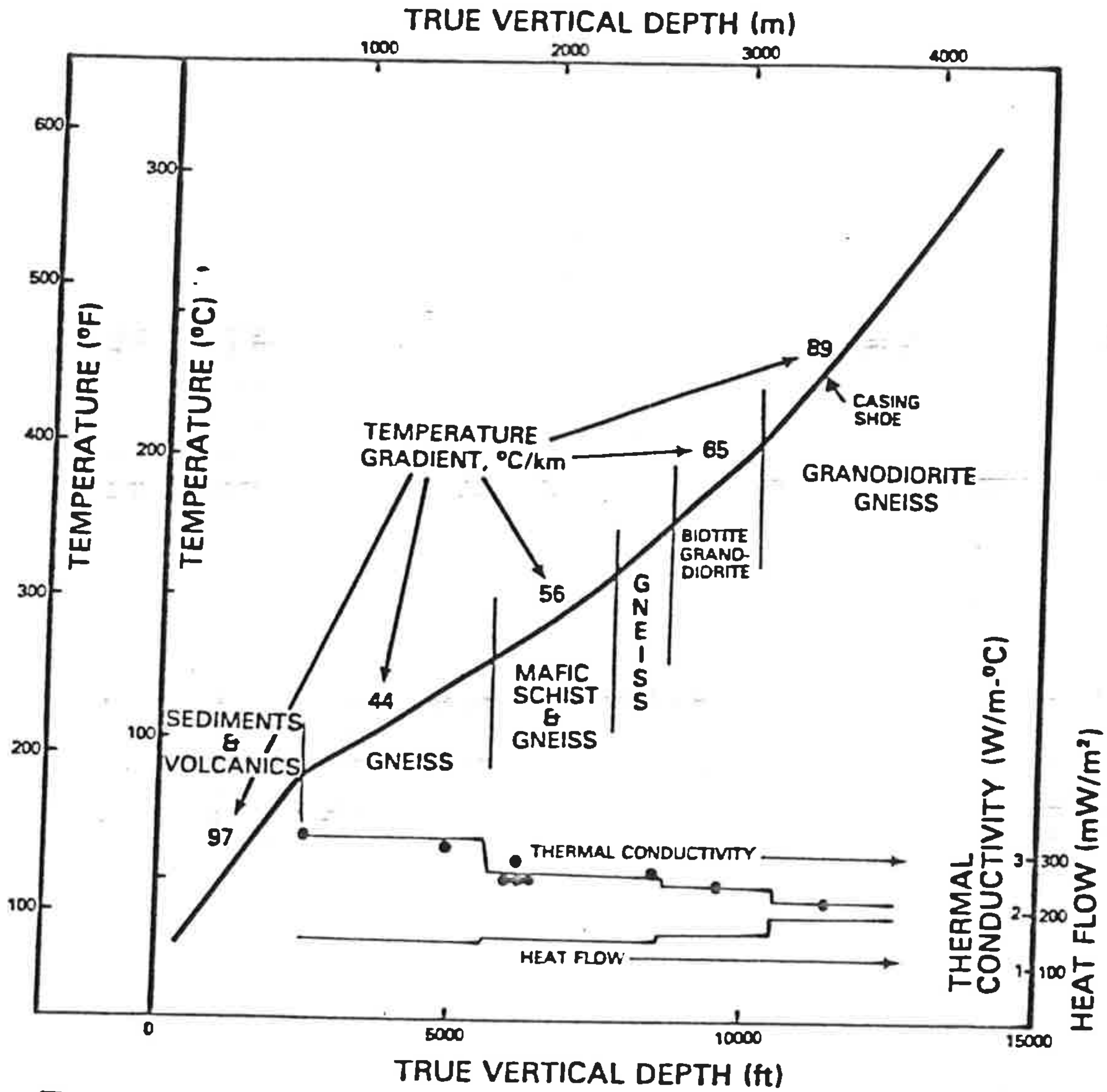

Fig. 3. EE-2 Temperature Distribution on August 12, 1980.

These temperature limits are stringent ones; we feel that such tools will not be developed in the time required, so that some cooling of the hole will be required to obtain logs.

Two methods of cooling the hole are available:

(1) Cool with circulation - water is pumped down an inner pipe, e.g. the drill string, and returned via the outer annulus.

(2) Cool by pumping water directly down the well and then into the surrounding formation near the bottom of the well.

Method (1) is inefficient since it requires counter-flow heat exchange in which the returning water heats the down-going injected water. It is also inefficient, as well as awkward, because first the inner string must be emplaced, cooling established, the string retrieved to the surface, and then the tool inserted and the log completed. On the other hand, method (2) is extremely effective in that no string is required and the heat transfer is direct, i.e., uniaxial flow. Furthermore, the logging tool can be emplaced, and possibly even used to actually log, while the cooling is occurring. Figure 4 shows typical results of cooling with method (2). The plots were generated by the code WBHT, mentioned earlier, and it shows that cooling by injecting 100 gpm of room-temperature water at the surface would result in bottom hole temperature of only 105°C (220°F) after about two days. If a particular tool needed quiescent conditions (no flow) for proper logging, a shut-in period of one-half day would result in a thermal recovery to 172C (341°F), within the capability of most "hot hole" tools.

(c) Resign of Phase II fractures. The LKFRK1 hydraulic fracturing code has been used to compare the effects of increasing fluid ijection volume, rate and viscosity on fracture length. A memo on the results is being written.

SUPPORTING RESEARCH

Geochemical Analysis. A new method, which relies upon organic solution extraction of heavy metals and subsequent measurement by atomic absorption, is being evaluated to expedite our analysis of trace metals in the reservoir effluent. In addition we are evaluating the use of a plasma emission spectrophotometer for automating chemical analyses.

Installation and start-up of ISI Scanning Electron Microscope. The Kevex energy dispersive analysis equipment was installed. This apparatus makes it possible to choose a small area or spot on a sample using the microscope and to perform an elemental analysis on the selected spot. This combination of microscopy and analysis will be used extensively in the analysis of high temperature cements. Using equipment at Cornell University we measured the freezing points of the liquids in the pore

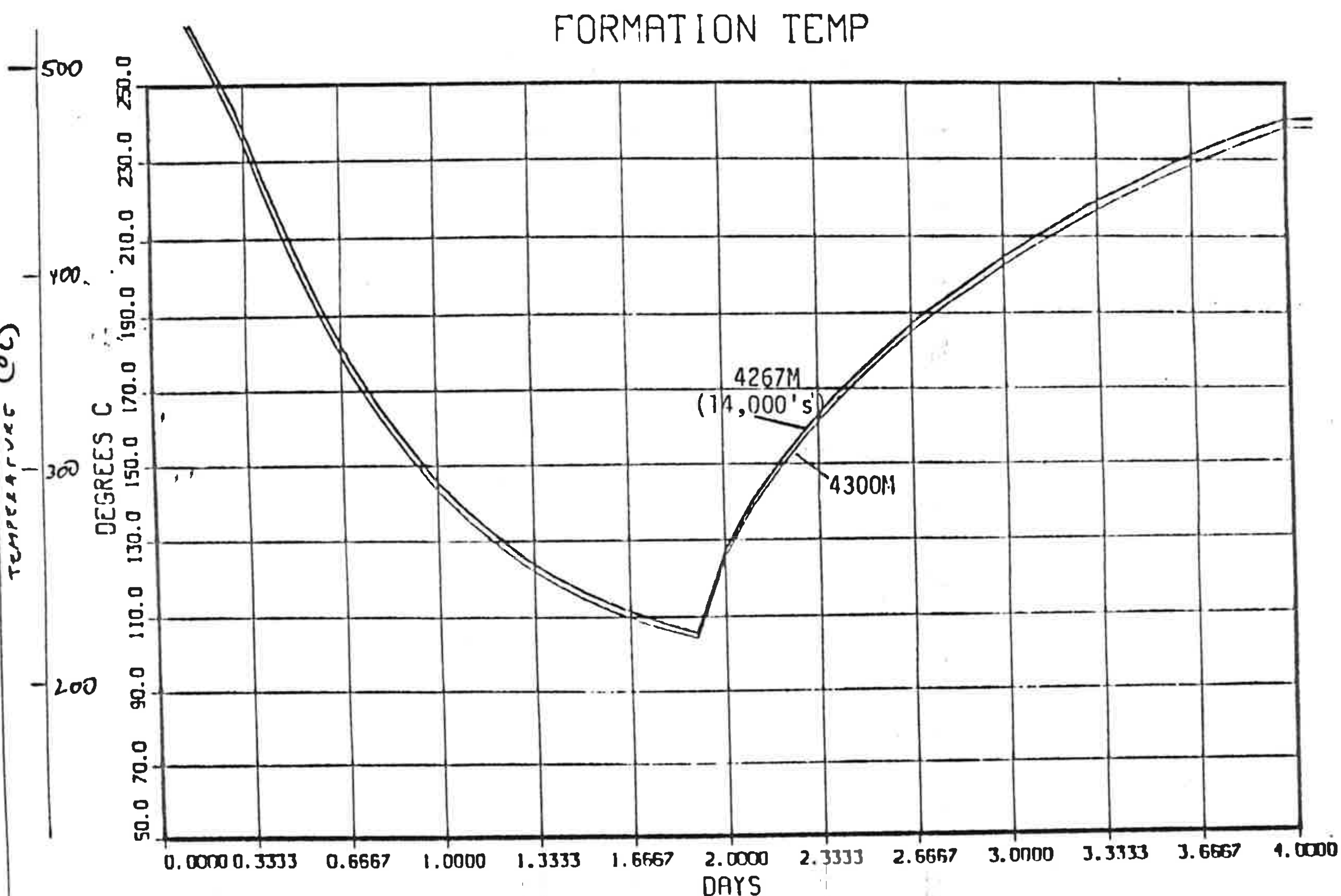

Figure 4. Bottom hole temperature change induced by cooling with 100 GPM.

inclusions in granite from GT-2B. Apparently this liquid does not freeze at temperatures of -25°C. However, there is a possibility that freezing took place but was unobservable because of the small size of the inclusions.

Several tools were made for opening these inclusions with a micromanipulator. These tools have sharp single crystal points made of BN and SiC. Using these tools mounted in the micromanipulator we were able to make some scratches across lines of inclusions. The scratched specimen must now be examined in the scanning electron microscope.

Dissolution of Drilling Fluid Residues. The test series for dissolving "Torque-Lube" residues with detergents at different temperatures and pressures was completed.

PUBLICATIONS

Grigsby, Charles O, P. E. Trujillo, Jr., D. A. Counce, R. E. Aguilar, "Geochemical Behavior of the Second Hot Dry Rock Geothermal Reservoir at Fenton Hill, New Mexico," to be presented at the 6th Annual Workshop on Geothermal Reservoir Engineering at Stanford University, Stanford, CA, December 16-18, 1980

Murphy, Hugh D., J. W. Tester and R. M. Potter, "Comparison of Two Hot Dry Rock Geothermal Reservoirs," to be presented at the 6th Annual Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA, December 16-18, 1980.

Zyvoloski, George, "Finite Element Methods for Geothermal Reservoir Simulation," in process for submission to International Journal for Numerical Methods in Engineering.

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